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ABSTRACT

A model of Academic Learning Time (ALT) is described, where ALT represents ongoing student learning in terms of student engagement, low student error rate, and relevance of the instructional task to the specified outcome. This model was validated in a correlational study of the relationship between these variables and student achievement in reading and mathematics. Achievement tests were administered to 139 second grade and 122 fifth grade students. ALT was measured during the inter-test period by direct observation and with records kept by teachers. These data were used to obtain student engagement rates, student error rates (low, medium, and high), and provided data on the instructional time allocated to specific content areas within reading and mathematics. Allocated time, engagement rate, and low error rate were found to be positively associated with student learning, while high error rate was negatively associated. These effects were generally consistent across both grade and content area. The set of four ALT variables accounted for an average of about 11 percent of the residual variance in achievement. These analyses provide strong support for the relationship of ALT to student learning. (Author/GDC)

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Academic Learning Time and Achievement: The Validation of a Measure of Ongoing Student Engagement and Task Difficulty

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ABSTRACT

Academic Learning Time and Achievement: The Validation of a Measure of Ongoing Student Engagement and Task Difficulty

Richard Marliave

A model of Academic Learning Time (ALT) is described, where ALT represents ongoing student learning in terms of student engagement, low student error rate, and relevance of the instructional task to the specified outcome. This model was validated in a correlational study of the relationship between these variables and student achievement. Data were collected at second grade (139 students in 25 classes) and fifth grade (122 students in 21 classes). Reading and mathematics achievement tests were administered in December and again in April-May. ALT was measured during the inter-test period by direct observation and with records kept by teachers. Trained observers collected data for one full day each week in each class. These data were used to obtain student engagement rates, student error rates (low, medium, and high), and general correction factors for the teacher records. The teacher records were kept on a daily basis. These records provided data on the instructional time allocated to specific content areas within reading and mathematics.

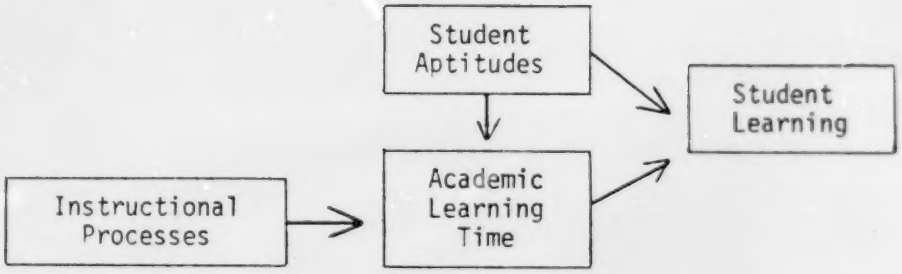
Multiple regression analyses were conducted, where posttest achievement scores were predicted by pretest scores, allocated time, engagement rate, low error rate, and high error rate. Analyses were conducted for total reading, total mathematics, and several subcategories within each of reading and mathematics. Allocated time, engagement rate, and low error rate were found to be positively associated with student learning, while high error rate was negatively associated ($p \leq .10$). Except for engagement rate at grade 2 mathematics and low error rate at grade 5 reading, these effects were consistent across both grade and content area. Furthermore, there was no case of a significant effect opposite in sign to that expected. The set of four ALT variables accounted for an average of about 11 percent of the residual variance in post achievement (after removing variance accounted for by pre achievement). In the strongest example, fractions at grade 5, the ALT variables accounted for 30 percent of the residual variance in achievement.

These analyses provide strong support for the relationship of ALT to student learning. This indicates that it is possible to measure ongoing student learning behaviors that are of considerable practical importance to both teachers and researchers.

Introduction

One of the major products of the line of research conducted for the Beginning Teacher Evaluation Study (BTES) has been a model of ongoing student learning, labeled academic learning time (ALT). It is intended that this model should describe classroom behaviors of students that manifest the ongoing occurrence of learning. Such a model, accompanied by instruments for measuring its component variables, should be a valuable tool for both educational practitioners and researchers. As portrayed in the schematic diagram below, the ALT model represents the link between instructional processes and student learning. This paper presents some of the major BTES findings relating ALT to student learning. The link between instructional processes and ALT is examined in an associated paper (Filby, 1978). A complete presentation of the BTES findings for instructional processes, ALT, and student learning will soon be available in the final report of the project (Fisher, Filby, Marliave, Cahen, Dishaw, Moore, and Berliner, 1978).

The findings to be presented here represent a first attempt to measure ongoing student learning behaviors, as represented by ALT, and to validate them against tests of achievement. Substantial support is demonstrated for the relationship between ALT and student learning. However, the BTES staff at Far West Laboratory believe that significant refinement of both the ALT model and its instrumentation are still warranted. The intent, here, is to show that learning in the form of ongoing student behaviors can be measured. Others are encouraged to contribute to the further elaboration of these behaviors and procedures for their measurement.



Schematic Overview of Academic Learning Time Model

Academic learning time (ALT). ALT involves engagement, low error rate, and task relevance to an academic outcome. Engagement refers to the involvement of the student in the learning activity under consideration. Obviously, no student learning can occur if there is no engagement. Therefore, the distinction between student engaged time and teacher allocation of time is critical. Allocated time is a function of teacher behavior, the assignment of a given activity to a specified period of student time. This is important, in that, it generally sets the limit for student engaged time in that particular activity. Nevertheless, there may be vast differences between allocated time and student engaged time. These differences may occur generally for an entire class or differentially across students within a class. Because student engagement in a learning activity is a necessary precondition for learning, ALT must include only engaged time.

Error rate on a task must be determined in relationship to the individual student. A given task will range from excessively easy to impossibly

difficult, depending upon the student for whom an error rate is being determined. In the ALT model, low error rate refers to a situation where the student produces only careless (or chance) errors. A moderate error rate involves a situation of partial knowledge, where the student understands enough to produce some correct responses, but also commits errors due to limitations in his/her understanding of the task. A high error rate is indicated when the student never responds correctly, except by guessing (a chance level of correct responses). Generally, it is expected that some balance between a low and a moderate error rate, with somewhat more activities at a low error rate than at a moderate error rate, will produce the most student learning. A high error rate would always be detrimental to learning conditions.

Task relevance to an academic outcome identifies the content category to which ALT is directed. A particular test might focus on a narrow range of content outcome categories, and therefore a narrow range of ALT. Clearly, if one attempts to relate ALT to gain on an achievement test, then ALT must be limited to those content categories that are relevant to that test.

The absence of ALT is also important. A great deal of student time in class consists of "Non-ALT" because the student is not engaged in any academic task or because the student's error rate on the task is excessively high. The usefulness of the concept, "Non-ALT," lies in the specification of its cause, either lack of engagement or an inappropriate student error rate. Hence, it is possible to analyze <u>why</u> learning does not occur.

A major strength of the ALT concept is that it focuses on an individual student and his ongoing learning behaviors. The model helps a teacher really "see" what individual students are doing in terms of their

observable classroom behavior. The power of this perspective lies in the fact that learning is an individual phenomenon, not a group phenomenon. Therefore, while managing the class as a group, the teacher must have some perspective for monitoring the ongoing learning of individual students.

Method

Data were collected on 139 second grade students from 25 classes and 122 fifth grade students from 21 classes. The classes of volunteer teachers were used. The student sample was obtained by selecting six students from each participating class on the basis of a selection test administered at the outset of the study. This test was designed to identify students of comparable entering achievement levels from each class so that the BTES achievement tests would be appropriate for all students in the study. Attrition, due to factors such as student absence during testing, resulted in an average of slightly less than six students per class.

Reading and mathematics achievement tests were administered to all participating students at the beginning of the school year (October, 1976), in early December, and at the end of the school year (April-May, 1977). These three testing occasions are referred to as A, B, and C, respectively. Extensive records of ALT were obtained during the inter-test periods by both observation and teacher record-keeping. This paper reports results from the second inter-test period (December to April), which is referred to as the "B-C period."

Observers were trained extensively over a three week period in the fall. Inter-observer reliability was established before data collection was initiated (Fisher, Filby, & Marliave, 1977). Two observers were assigned to each class and one full day of observation was conducted each week in each class throughout the inter-test periods.

Teachers were trained for record-keeping of allocated instructional time at an intensive one-day session before the study began (Dishaw, 1977). Evaluative tests were administered at the end of the day of training. Thereafter, the observers monitored individual teachers for their record-keeping accuracy during the course of the study. Corrective feedback was

provided where necessary.

Engagement rates were obtained for each student on the basis of observational data. Observers recorded the number of minutes that each student was engaged (paying attention) in reading or mathematics activities during a school day, as well as the amount of time that a student was not engaged. These data were used to compute the proportion of total time, in reading or mathematics, that a student was engaged over the course of the study (one day per week of observation data, combined for both of the inter-test periods). The determination of an overall engagement rate for each student provided assessment of engagement as a trait-like variable. The major purpose of this procedure was to increase the reliability of the variable (Marliave, Fisher, & Dishaw, 1977). As a result, two estimates of engagement rates were obtained for each student, one for reading and one for mathematics. No distinction was made between engagement during the two inter-test periods nor between engagement in any of the various content skill areas within reading or mathematics.

Error rates were also obtained for each student on the basis of observational data. Observers recorded the daily time, in minutes, that each student spent during reading or mathematics at each of the three error rate levels, low, medium, and high. Low error time was recorded when students were responding to a task with no errors other than careless mistakes (attributable to chance). Medium error was coded when students responded with a mixture of errors and correct responses, somewhere between the low and high error rate categories. High error was coded when students showed no correct responses, except what was attributable to guessing (a chance proportion of correct responses). The error rate data were compiled similarly to the engagement data, in that proportions of total reading or

mathematics time in each error category were computed over both inter-test periods combined. Again, this procedure was used to increase the reliability of the error rate estimates (Marliave, et al., 1977). This provided six estimates of error rate for each student: low, medium, and high in each of reading and mathematics. Analyses were conducted only for the low and high error rate variables, because the low and medium categories were essentially ipsative. (This was due to the fact that the high error category was a relatively rare occurrence, so that most activities fell into either the low or the medium error category.)

Records of allocated time within various skill and concept areas in reading and mathematics were obtained from teachers. These records were maintained on a daily basis for each student throughout the study. The observers also recorded allocated time within various content categories, but only during the single day of observation each week. However, observer records of allocated time were compared with teacher records on corresponding days. Observer-teacher allocated time ratios were computed for total reading time and for total mathematics time, across all the corresponding days for a given teacher. This ratio was applied to the teacher records of allocated time as a means of correcting them for general tendencies to over- or under-estimate total time in reading or mathematics (Marliave, et al., 1977).

The allocated time data, using the adjusted teacher records described above, were compiled for each inter-test period separately and for each of several skill and concept areas within reading and mathematics. Analyses showed that the teacher records of allocated time agreed satisfactorily with observer records, even before the adjustment (Marliave, et al., 1977). Furthermore, the teacher records covered every school day in each inter-test

period, so that they did not involve sampling as did the observational data (which were collected only one day per week). Therefore, it was not necessary to aggregate the allocated time data across the inter-test periods and across all the reading and mathematics categories, in order to obtain acceptable reliability.

Results

Descriptive data on ALT are presented in Table 1. Means and standard deviations are given for engagement rate, low error rate, and high error rate. Note that the average engagement rate for the B-C period was between 70 and 75 percent for both grades (2 and 5) and both content domains (reading and mathematics). One reason for these relatively high rates of engagement was the exclusion of transitional activities from allocated reading and mathematics time as recorded for this study. That is, time during which students were moving from one activity to another, or simply waiting for the next activity to begin, was excluded from the allocated reading and mathematics categories. This time might otherwise have been recorded as non-engaged reading and mathematics time. As discussed previously, teacher records of total reading and mathematics allocations were adjusted according to observer data. This adjustment assured that the exclusion of transitional activities from reading and mathematics allocations, for which the observers were carefully trained, was consistently applied to the teacher records of allocated time.

Table 1 also indicates that the high error rate category accounts for a very small proportion of instructional time, ranging from one to five percent. The low error rate category accounts for one-third to one-half of the remaining time. All other instructional time in reading and mathematics was coded as medium error rate (the only other category possible). Therefore, the low and medium error rates account for the vast majority of instructional time, so that these two categories are essentially ipsative (as discussed previously). For this reason, only one of these two categories, low error rate, was included in the analyses.

The relationship between ALT and student learning was analyzed with

Table 1

Descriptive Data

Academic Learning Time (B-C Period)

Grade	Content Domain	Proportion Engaged	Proportion Low Error Rate	Proportion High Error Rate
2 (N=139)	Reading	.74 (.10)	.50 (.18)	.02 (.03)
2 (N=139)	Mathematics	.70 (.12)	.50 (.21)	.05 (.07)
5 (N=122)	Reading	.75 (.11)	.46 (.15)	.01 (.02)
5 (N=122)	Mathematics	.73 (.13)	.34 (.21)	.03 (.06)

Entries are: Mean (Standard Deviation)

multiple regression techniques. Student achievement at the end of the school year (the C testing) was predicted by B test scores (in December), allocated time during the B-C period, engagement rate, low error rate, and high error rate. Analyses were conducted on all students pooled (for students at grades 2 and 5 separately).[1] Twenty-nine regressions were conducted.

The results of these analyses are presented in Tables 2 through 5. These four tables represent grade 2 reading, grade 2 mathematics, grade 5 reading, and grade 5 mathematics respectively. Each table has the same format. Each row presents information on one multiple regression. The content categories for post achievement, pre achievement, and allocated time are presented in the first three entries of a row (left side). The next four entries give the regression coefficients and associated probabilities for the four ALT variables (allocated time, engagement rate, low error rate, and high error rate). The sign of the regression coefficient indicates the direction (positive or negative) of the variable's effect on post achievement (C test). The probability associated with a coefficient indicates how likely it is that the effect is due to chance. The last seven entries in a row indicate what proportion of the variance in post achievement is accounted for by a given variable or set of variables. The first four of these give the unique contribution of each variable, while the fifth gives the joint contribution of all four ALT variables as a set. The next entry indicates how much post achievement variance is accounted for by the total regression (pre achievement and the four ALT variables,

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1. Additional analyses of ALT and student learning in the B-C period are reported in Technical Note V-1b (Marliave, Fisher, & Dishaw, 1978).

Table 2

Regressions Analyzing the Combined Effects of ALT Variables

Analyses of Reading Achievement in Grade 2 for the B-C Period, Regressing Post Achievement on Pre Achievement, Allocated Time, Engagement Rate, Low Error Rate, and High Error Rate (N=139).

Dependent Variable	Independent Variables Other than Engagement Rate, Low Error, and High Error		β as a raw coefficient Probability ≤ (in parentheses)				Proportion of Total Variance Accounted for Uniquely[a]						Residual Variance, Combined ALT Variables[d]
Post Achievement	Pre Achievement	Time	Allocated Time	Engagement Rate	Low Error Rate	High Error Rate	Allocated Time	Engagement Rate	Low Error Rate	High Error Rate	Combined ALT Variables[b]	Total Regression[c]	
Total Comprehension	Total Comprehension	Total Comprehension	0.0005 (.77)	2.0 (.72)	5.1 (.12)	-10.0 (.59)	.00	.00	.01	.00	.02	.34	.03
Decoding Blends and Long Vowels	Decoding Blends and Long Vowels	Decoding Blends and Long Vowels	0.0033 (.02)	9.5 (.02)	5.0 (.05)	-31.7 (.02)	.02	.02	.01	.02	.09	.58	.17
Decoding Variant Consonants	Decoding Variant Consonants	Decoding Variant Consonants	0.0056 (.31)	4.7 (.25)	7.9 (.01)	-4.9 (.72)	.01	.01	.07	.00	.11	.23	.13
Word Structure Meaningful Units	Word Structure Meaningful Units	Word Structure Meaningful Units	0.0021 (.22)	1.3 (.69)	2.2 (.29)	-4.4 (.70)	.01	.00	.00	.00	.01	.50	.03
Syllables	Syllables	Syllables	0.0085 (.01)	1.3 (.59)	3.3 (.02)	-9.0 (.26)	.05	.00	.03	.00	.13	.22	.14
Decoding Complex Patterns	Decoding Complex Patterns	Spelling	0.0017 (.07)	5.1 (.10)	7.6 (.01)	-11.6 (.27)	.01	.01	.05	.00	.11	.58	.21
Total Reading	Total Reading	Total Reading	0.0013 (.33)	20.6 (.18)	22.1 (.03)	-87.3 (.10)	.00	.00	.01	.01	.04	.72	.11

[a] Given the five predictor model, this is the variance accounted for uniquely by the independent variable specified.

[b] The ALT variables are Allocated Time, Engagement Rate, Low Error Rate, and High Error Rate.

[c] This is the R squared for the multiple regression (the combined effect of Pre Achievement and the four ALT variables).

[d] "Residual variance" refers to the variance remaining in the Post Achievement measure after Pre Achievement is "removed." This column reports the proportion of this residual variance that is accounted for by the set of ALT variables.

Table 3

Regressions Analyzing the Combined Effects of ALT Variables

Analyses of Mathematics Achievement in Grade 2 for the B-C Period, Regressing Post Achievement on Pre Achievement, Allocated Time, Engagement Rate, Low Error Rate, and High Error Rate (N=139).

Dependent Variable	Independent Variables Other than Engagement Rate, Low Error, and High Error		B as a raw coefficient Probability ≤ (in parentheses)				Proportion of Total Variance Accounted for Uniquely[a]						Residual Variance, Combined ALT Variables[d]
Post Achievement	Pre Achievement	Time	Allocated Time	Engagement Rate	Low Error Rate	High Error Rate	Allocated Time	Engagement Rate	Low Error Rate	High Error Rate	Combined ALT Variables[b]	Total Regression[c]	
Addition and Subtraction No Regrouping	Addition and Subtraction No Regrouping	Addition and Subtraction No Regrouping	-0.0005 (.78)	1.7 (.72)	5.4 (.04)	-1.9 (.81)	.00	.00	.02	.00	.03	.28	.04
Speeded Tests	Speeded Tests	Speeded Tests	0.0148 (.02)	5.5 (.17)	11.0 (.01)	-0.9 (.89)	.02	.01	.09	.00	.14	.49	.22
Computational Transfer	Computational Transfer	Computational Transfer	0.0014 (.33)	0.3 (.93)	5.6 (.01)	1.3 (.85)	.00	.00	.03	.00	.04	.36	.06
Place Value and Numerals	Place Value and Numerals	Place Value and Numerals	-0.0010 (.67)	-2.9 (.43)	1.2 (.59)	-.58 (.37)	.00	.00	.00	.00	.01	.48	.01
Word Problems	Word Problems	Word Problems	0.0049 (.10)	0.4 (.90)	1.4 (.37)	-8.0 (.10)	.01	.00	.00	.01	.05	.32	.07
Money	Money	Money	-0.0005 (.78)	1.8 (.28)	1.7 (.09)	-6.6 (.02)	.00	.01	.01	.02	.08	.42	.12
Linear Measurement	Linear Measurement	Linear Measurement	0.0000 (.99)	0.2 (.86)	1.2 (.13)	-2.2 (.33)	.00	.00	.01	.01	.03	.22	.04
Fractions	Computational Transfer	Fractions	0.0126 (.01)	-0.6 (.81)	1.6 (.27)	2.0 (.66)	.10	.00	.01	.00	.10	.15	.11
Addition and Subtraction with Regrouping	Addition with Regrouping	Addition and Subtraction with Regroup-Algorithms	0.0046 (.04)	7.8 (.16)	5.1 (.11)	4.4 (.66)	.03	.01	.02	.00	.06	.12	.06
Total Math	Total Math	Total Math	0.0005 (.88)	15.3 (.33)	19.8 (.03)	-4.5 (.87)	.00	.00	.01	.00	.02	.61	.06

[a] Given the five predictor model, this is the variance accounted for uniquely by the independent variable specified.

[b] The ALT variables are Allocated Time, Engagement Rate, Low Error Rate, and High Error Rate.

[c] This is the R squared for the multiple regression (the combined effect of Pre-Achievement and the four ALT variables).

[d] "Residual variance" refers to the variance remaining in the Post Achievement measure after Pre Achievement is "removed." This column reports the proportion of this residual variance that is accounted for by the set of ALT variables.

Table 4

Regressions Analyzing the Combined Effects of ALT Variables

Analyses of Reading Achievement in Grade 5 for the B-C Period, Regressing Post Achievement on Pre Achievement, Allocated Time, Engagement Rate, Low Error Rate, and High Error Rate (N=122).

Dependent Variable	Independent Variables Other than Engagement Rate, Low Error, and High Error		B as a raw coefficient Probability ≤ (in parentheses)				Proportion of Total Variance Accounted for Uniquely[a]						Residual Variance, Combined ALT Variables[d]
Post Achievement	Pre Achievement	Time	Allocated Time	Engagement Rate	Low Error Rate	High Error Rate	Allocated Time	Engagement Rate	Low Error Rate	High Error Rate	Combined ALT Variables[b]	Total Regression[c]	
Total Word Meaning	Total Word Meaning	Total Word Meaning	-0.0019 (.47)	23.6 (.01)	-0.4 (.92)	-30.8 (.31)	.00	.04	.00	.00	.05	.74	.15
Total Comprehension	Total Comprehension	Total Comprehension	0.0026 (.01)	-3.4 (.56)	-0.7 (.87)	-88.9 (.01)	.05	.00	.00	.02	.07	.74	.21
Syllables	Syllables	Syllables	-0.0016 (.73)	2.7 (.47)	-0.7 (.79)	-44.0 (.03)	.00	.00	.00	.03	.03	.38	.05
Total Reading	Total Reading	Total Reading	0.0014 (.12)	16.7 (.16)	-11.7 (.20)	-121.6 (.05)	.00	.00	.00	.01	.03	.79	.11

[a] Given the five predictor model, this is the variance accounted for uniquely by the independent variable specified.

[b] The ALT variables are Allocated Time, Engagement Rate, Low Error Rate, and High Error Rate.

[c] This is the R squared for the multiple regression (the combined effect of Pre Achievement and the four ALT variables).

[d] "Residual variance" refers to the variance remaining in the Post Achievement measure after Pre Achievement is "removed." This column reports the proportion of this residual variance that is accounted for by the set of ALT variables.

Table 5

Regressions Analyzing the Combined Effects of ALT Variables

Analyses of Mathematics Achievement in Grade 5 for the B-C Period, Regressing Post Achievement on Pre Achievement, Allocated Time, Engagement Rate, Low Error Rate, and High Error Rate (N=122).

Dependent Variable	Independent Variables Other than Engagement Rate, Low Error, and High Error		B as a raw coefficient Probability ≤ (in parentheses)				Proportion of Total Variance Accounted for Uniquely[a]						Residual Variance, Combined ALT Variables[d]
Post Achievement	Pre Achievement	Time	Allocated Time	Engagement Rate	Low Error Rate	High Error Rate	Allocated Time	Engagement Rate	Low Error Rate	High Error Rate	Combined ALT Variables[b]	Total Regression[c]	
Total Geometry	Total Geometry	Total Geometry	0.0016 (.52)	6.1 (.06)	-1.9 (.38)	-12.7 (.06)	.00	.03	.01	.03	.06	.18	.07
Total Multiplication	Total Multiplication	Total Multiplication	0.0007 (.50)	-1.4 (.64)	3.6 (.12)	18.7 (.01)	.00	.00	.01	.04	.07	.40	.11
Division	Division	Division	0.0010 (.30)	-4.1 (.22)	-0.5 (.82)	-19.3 (.01)	.01	.01	.00	.04	.06	.36	.09
Fractions	Fractions	Fractions	0.0027 (.01)	3.7 (.15)	-2.2 (.20)	-13.8 (.01)	.12	.01	.01	.03	.22	.50	.30
Computational Transfer	Computational Transfer	Computational Transfer	-0.0001 (.94)	-2.6 (.26)	2.9 (.06)	-12.4 (.01)	.00	.00	.01	.02	.04	.62	.10
Word Problems	Word Problems	Word Problems	-0.0007 (.58)	0.0 (1.00)	0.3 (.82)	-3.5 (.37)	.00	.00	.00	.00	.00	.38	.01
Multiplication Speeded Test	Multiplication Speeded Test	Basic Multiplication Facts	0.0096 (.08)	8.2 (.06)	5.7 (.05)	1.4 (.89)	.01	.01	.01	.00	.05	.69	.13
Total Math	Total Math	Total Math	0.0062 (.01)	1.5 (.89)	2.4 (.73)	-41.3 (.10)	.02	.00	.00	.01	.02	.72	.08

[a] Given the five predictor model, this is the variance accounted for uniquely by the independent variable specified.

[b] The ALT variables are Allocated Time, Engagement Rate, Low Error Rate, and High Error Rate.

[c] This is the R squared for the multiple regression (the combined effect of Pre Achievement and the four ALT variables).

[d] "Residual variance" refers to the variance remaining in the Post Achievement measure after Pre Achievement is "removed." This column reports the proportion of this residual variance that is accounted for by the set of ALT variables.

comprising a five variable set). The final entry in each row gives the proportion of "residual variance" accounted for by the set of four ALT variables, where "residual variance" refers to the variance remaining in post achievement after pre achievement is "removed."

When examining these four tables, it should be noted that the achievement and time content categories in the bottom row are always total reading or total mathematics. The preceding rows in each table always represent sub-categories of total reading or mathematics. Furthermore, the sum of the sub-categories is always equal to total reading or mathematics, as defined for this study.

The results for Tables 2 through 5 are summarized in Table 6. Each row in Table 6 summarizes the results for one of the four preceding tables. The first two entries in each row give the grade (2 or 5) and content domain (reading or mathematics) of the regressions summarized. The next entry gives the total number of these regressions. The next four entries give the number of significant regression effects and their sign (positive or negative) for each of the four ALT variables. The final entry in each row indicates the average proportion of "residual variance" accounted for by the set of four ALT variables in the regressions summarized.

The summary of results in Table 6 indicates that allocated time, engagement rate, and low error rate are each positively associated with achievement outcomes. High error rate is negatively associated with achievement. In no case was there a significant negative effect ($p \leq .10$) for time, engagement, or low error, nor a significant positive effect for high error. However, engagement in grade 2 mathematics and low error in grade 5 reading showed no significant effects. Nevertheless, the results are quite consistent overall. Furthermore, the set of ALT variables

Table 6

Summary of Regressions

Combined Effects of ALT Variables

Regression of Post Achievement on Pre Achievement, Allocated Time, Engagement Rate, Low Error Rate, and High Error Rate (B-C Period).

Grade	Content Domain	Total Number of Regressions	Number of significant effects ($p \leq .10$) positive + or negative -				Average Residual Variance, Combined ALT Variables[a]
			Allocated Time	Engagement Rate	Low Error Rate	High Error Rate	
2 (N=139)	Reading	7	3+	2+	5+	2-	.12
2 (N=139)	Mathematics	10	4+	0	5+	2-	.08
5 (N=122)	Reading	4	1+	1+	0	3-	.13
5 (N=122)	Mathematics	8	3+	2+	2+	6-	.11

[a] "Residual variance" refers to the variance remaining in the Post Achievement measure after Pre Achievement is "removed." This column reports the proportion of this residual variance that is accounted for by the set of ALT variables.

accounts for an average of about 11 percent of the "residual variance" in achievement. In the strongest example, fractions at grade 5 (Table 5), the ALT variables account for 30 percent of the "residual variance."

Summary and Conclusions.

The findings of this study show a strong and consistent effect of the ALT variables in relationship to student learning outcomes. These variables as a set, account for an average of about 11 percent of residual variance after pre-achievement is "removed." Furthermore, the effects are generally consistent across grade and subject matter, where allocated time, engagement rate, and low error rate show a positive relationship with learning, and high error rate shows a negative relationship with learning.

Simply put, it may be concluded that students who spend more time in an instructional activity, at a relatively high level of attention, and producing a relatively low number of errors, will learn more of the content of that instructional activity. It may also be concluded that about one tenth of the measured learning shown by students can be accounted for by data on their time, attention, and error rates.

It could be argued that the association of time, attention, and error rate with learning is an obvious one. One might futher contend that one tenth of student learning outcomes is a small effect. On the other hand, the conceptual clarity of the time, attention, and error rate relationship with learning could be seen as futher substantiation of the empirical relationships found. Educational relationships are much more believable it they are supported by good sense, as well as empirical data. Furthermore, the explanation of one tenth of student learning is surely of considerable importance. Any detectable portion of student learning is important, in relationship to the enormous impact upon society of the knowledge acquired by its members. In addition, It is most likely that this is an underestimation of the true effect of

the ALT variables upon student learning. Measurement in educational field research is known to suffer chronic inaccurracy, so that much of the unexplained variance in student learning is actually some form of error variance.[2] Thus, the true relationship between associated variables is generally much greater than their measured relationship.

A more fundamental point should be made on the results of this study. Ongoing student behaviors in the classroom have been shown to relate strongly and consistently to student learning outcomes. This represents a reasonably successful early attempt to measure the ongoing learning process itself. The measurement of ongoing learning is of considerable importance to teachers and researchers. It offers immediate feedback on the strengths and weaknesses of instructional events. It pinpoints those student behaviors (or the lack thereof) that obstruct learning. Furthermore, it allows for continuous monitoring of learning events without disrupting or actually displacing those events (as testing does).

ALT should be conceived more broadly than the particular variables measured here. Student attention to an instructional task is one variable in a cluster of affective-motivational student learning behaviors. Error rate is one variable in a cluster of cognitive student response variables. Allocated time in a content category is one variable in a cluster of dimensions characterizing instructional tasks. It is clear that considerable elaboration of the variables and instruments used in this study is both possible and desirable. The effectiveness of these variables and instruments in their current, rather simple, form is a promising indication of what might be attained by the measurement of student learning in terms of ongoing behavior in the classroom.

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2. See Boruch & Gomez (1977) for a full elaboration of this point.

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